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Jeppesen, Maja Mønster; Thygesen, Lau Caspar; Ekeloef, Sarah; Gögenur, Ismail

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A nationwide cohort study of short- and long-term outcomes following emergency laparotomy

Maja Mønster Jeppesen[1], Lau Caspar Thygesen[2], Sarah Ekeloef[1] & Ismail Gögenur[1]

ABSTRACT

INTRODUCTION: Emergency laparotomy is a high-risk procedure associated with severe post-operative morbidity and high mortality. The aim was to conduct a nationwide cohort consisting of all patients undergoing emergency laparotomy during an 11-year period and to examine both short- and long-term outcomes.

METHODS: Adult patients treated with emergency laparotomy due to gastrointestinal conditions from 2003 through 2013 were identified in the Danish National Patient Register. Demographic data and surgical outcomes were identified in nationwide registers.

RESULTS: A total of 47,300 patients were included in the study. Hereof, 15,015 patients underwent minor laparotomy (open appendectomy or cholecystectomy) and the rest underwent major laparotomy (n = 32,285). In all, 8,193 patients (17.3%) were readmitted within 30 days from surgery, whereas 7,521 patients (15.9%) underwent gastrointestinal reoperation. A total of 10,944 patients (23.1%) experienced a post-operative complication. The post-operative mortality at 7, 30, 90 and 365 days was 8.5%, 13.3%, 16.9% and 21.9%, respectively. When excluding minor laparotomies (open appendectomy and cholecystectomy), the 7-, 30-, 90- and 365-day mortality was 12.1%, 18.7%, 23.6% and 30.5%, respectively.

CONCLUSIONS: More than one in every five patients died within one year after undergoing emergency laparotomy, and mortality rates were even higher when excluding minor laparotomies as almost one in every three patients died within one year.

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TRIAL REGISTRATION: The study was registered with Researchregistry.com (Id no: researchregistry2930).

Emergency laparotomy is a frequent procedure in general surgery. It is known as a high-risk procedure with a 30-day mortality of 11-20% [1-6], and up to 30% of patients experience major short-term post-operative complications such as sepsis, anastomotic leakage and cardiopulmonary complications [3, 5, 7]. Only few studies have examined the long-term outcomes following emergency laparotomy [3, 7-9].

In recent years, considerable efforts have been put into improving the outcomes following elective surgery. Even so, the same development is lacking in the area of emergency surgery, although it constitutes a considerable health burden worldwide [10]and emergency conditions requiring surgery contribute substantially to the global disease burden. Methods This was a review of studies that contributed to define the population-based health burden of emergency surgical conditions (excluding trauma and obstetrics. Previous studies examining outcomes following emergency laparotomies were mainly procedure specific (e.g., perforated ulcer or small bowel obstruction) [1, 11]. There is a need for studies based on unselected, nationwide data to identify important trends in the short- and long-term post-operative morbidity and mortality and to establish preventive measures.

The aim of this study was to conduct a nationwide cohort study including all patients who had undergone emergency laparotomy in Denmark during an 11-year period. We examined the short- and long-term mortality risk and assessed the frequency of gastrointestinal reoperations, acute readmissions and post-operative complications.

METHODS

Data sources

This was a nationwide, population-based cohort study. The study was based on two Danish registers; the Danish National Patient Register (NPR) [12] and the Civil Registration System (CRS) [13]. Data from these registers were linked via the personal civil registration number (CPR number). The CRS is 100% complete and contains information on all citizens with permanent residence in Denmark [13]. Information on mortality, country of origin and marital status was obtained from the CRS. The NPR contains information regarding all hospital contacts and surgeries performed in Denmark since 1977. We obtained all data concerning admissions, diagnoses and surgeries for this study from the NPR.

Study population

Patients aged 18 years or above who underwent an

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1) Center for Surgical Science, Department of Surgery, Zealand University Hospital
2) National Institute of Public Health, University of Southern Denmark, Denmark

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emergency laparotomy between 1 January 2003 and 31 December 2013 were identified. The patients were extracted from the NPR using their surgical codes. In the NPR, surgical codes are classified by the Danish version of the NOMESCO Classification of Surgical Procedures (NCSP). The NCSP is divided into chapters according to the anatomical location of the surgery, and every surgery performed is coded by a primary surgical code and optional secondary surgical codes.

The study population consisted of patients with a primary surgical code indicating a laparotomy due to gastrointestinal (GI) conditions (NCSP chapter KJ), independent of any secondary surgery codes, (Supplemental digital content 1 [14]). In order to exclude lective procedures, only patients with an admission registered as acute and surgery performed within 72 hours from admission were included. Patients who had undergone abdominal surgery within 30 days prior to the admission were excluded in order to exclude reoperations.

Outcome measures

The primary outcome measure of the present study was short- and long-term mortality. We present the mortality risk at the day of surgery and 7, 30, 90 and 365 days after laparotomy. The secondary outcomes were the frequency of GI reoperations, acute readmissions and post-operative complications at 30 and 90 days following surgery.

A GI reoperation was defined as one or more surgeries of the digestive system. A minimum of four hours between the index surgery and reoperation was required in order to ensure that the surgeries were separate procedures.

A readmission was recorded if the admission was registered as acute, and only readmissions caused by specific indications were considered. The indication for readmission had to be common complications to surgery (Supplemental digital content 2 [14]). A minimum of four hours between discharge and readmission were required in order to exclude transfers between departments [15].

Post-operative complications were examined by preselected diagnosis codes (Supplemental digital content 3 [14]). All diagnoses from the index admission and diagnoses administered to the patients in the period within 30 and 90 days of their surgery were examined. We included in- and outpatient contacts and emergency room visits.

The study population was divided into two groups termed minor and major laparotomy. Patients who had been through an open appendectomy (KJEA00) or an open cholecystectomy (KJKA00, KJKA10, KJKA20) were included in the "minor laparotomy" group. The remaining study population was included in the "major laparotomy" group. This division was made in order to compensate for the difference in demographics and outcomes seen for major and minor open procedures [2].

Other covariates

The descriptive data included age, gender, marital status, and nationality. The most common diagnoses of admission were presented in International Classification of Diseases, tenth revision (ICD-10) chapters. The most common surgical codes were presented separately and in NCSP chapters. We examined the preoperative comorbidity of the study population by the Charlson comorbidity score based on the patients' ICD-10 diagnostic codes from the NPR up to ten years before admission [16]. The Charlson comorbidity score is generated from 19 comorbid conditions. The comorbidities are selected and weighted according to their influence on one-year mortality and then summed to a total score with higher scores denoting severe comorbidity [16].

Statistics

Descriptive statistics of categorical variables were presented as absolute numbers with percentages and continuous variables as medians with interquartile ranges. The primary endpoint was presented as mortality risk with 95% confidence intervals (CI), and by a survival Kaplan-Meier curve stratified by minor and major surgery. The 30- and 90-day mortality risks were stratified by the calendar year of the index surgery and the type of surgery with 95% CI. The Danish health registries are of a very high quality and follow-up is virtually complete. Complete-case analysis was used. Descriptive statistics were performed using the SAS Proprietary Software 9.3 (SAS Institute Inc., Cary, North Carolina USA). The study was approved by The Danish Data Protection Agency (record no.: 2015-57-0008). According to the aim of the study, it is reported in accordance with the STROBE guidelines for cohort studies.

Trial registration: The study was registered with Researchregistry.com (Id no: researchregistry2930).

RESULTS

Descriptive data

The study population was selected from 269 surgical codes. When excluding elective procedures, the study population consisted of 47,300 patients, and 216 of the surgical codes were represented (Supplemental digital content 1 [14]). A total of 32,285 patients (68.3%) underwent major laparotomy (**Table 1**).

Surgeries

The most common anatomical location of surgery was the intestine (17,792; 37.6%) and appendix (13,021;

TABLE 1

Descriptive statistics and surgical outcomes of patients undergoing emergency laparotomies, Denmark, 2003-2013.

Characteristics	All patients (N = 47,300)	Minor laparotomies (N = 15,015)	Major laparotomies (N = 32,285)
Gender, male, n (%)	22,754 (48.1)	8,066 (53.7)	14,688 (45.5)
Age, median (IQR), yrs	61 (43-75)	44 (30-62)	67 (53-78)
Marital status, n (%)			
Single	10,619 (22.5)	5,273 (35.2)	5,346 (16.6)
Married	22,449 (47.5)	7,150 (47.6)	15,299 (47.4)
Widow	8,190 (17.3)	1,157 (7.7)	7,033 (21.9)
Divorced	6,042 (12.7)	1,435 (9.6)	4,607 (14.3)
Nationality, n (%)			
Danish	44,690 (94.5)	14,030 (93.4)	30,660 (95.0)
Other	2,610 (5.5)	985 (6.6)	1,625 (5.0)
Primary diagnosis for admission, n (%)[a]			
C00-D48: Neoplasms	4,736 (10.0)	107 (0.7)	4,629 (14.3)
K00-K93: Diseases of the digestive system	33,987 (71.8)	13,470 (89.7)	20,517 (63.6)
R00-R99: Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	2,012 (4.4)	770 (5.1)	1,242 (3.9)
S00-T98: Injury, poisoning and certain other consequences of external causes	2,089 (4.3)	39 (0.3)	2,050 (6.4)
Z00-Z99: Factors influencing health status and contact with health services	1,266 (2.7)	189 (1.3)	1,077 (3.4)
Charlson comorbidity score, n (%)			
0	17,809 (37.7)	9,641 (64.2)	8,168 (25.3)
1-2	14,839 (31.4)	3,488 (23.2)	11,351 (35.2)
3-4	7,603 (16.1)	1,159 (7.7)	6,444 (20.0)
≥ 5	7,049 (14.9)	727 (4.8)	6,322 (19.6)
Time to surgery, median (IQR), h	11 (5-24)	9 (5-20)	11 (5-25)
Length of stay, median (IQR), days	7 (3-13)	3 (2-6)	9 (5-16)
Reoperation, n (%)			
Within 30 days	7,521 (15.9)	1,294 (8.6)	6,227 (19.3)
Within 90 days	8,711 (18.4)	1,476 (9.8)	7,235 (22.4)
Readmission, n (%)			
Within 30 days	8,193 (17.3)	2,299 (15.3)	5,894 (18.3)
Within 90 days	10,956 (23.2)	2,708 (18.0)	8,248 (25.6)
Complications within 30 days, n (%)	10,944 (23.1)	1,912 (12.7)	9,032 (28.0)
Renal and endocrine	2,369 (5.0)	198 (1.3)	2,171 (6.7)
Wounds	1,699 (3.6)	214 (1.4)	1,485 (4.6)
Infections	5,489 (11.6)	1,371 (9.1)	4,118 (12.8)
Pulmonary	2,441 (5.2)	164 (1.1)	2,277 (7.1)
Cardiovascular	2,568 (5.4)	248 (1.7)	2,320 (7.2)
Neurological	482 (1.0)	44 (0.3)	438 (1.4)
Complications within 90 days, n (%)	12,345 (26.1)	2,076 (13.8)	10,269 (31.8)
Renal and endocrine	3,017 (6.4)	240 (1.6)	2,777 (8.6)
Wounds	1,886 (4.0)	244 (1.6)	1,642 (5.1)
Infections	6,324 (13.4)	1,464 (9.8)	4,860 (15.1)
Pulmonary	2,651 (5.6)	179 (1.2)	2,472 (7.7)
Cardiovascular	3,008 (6.4)	297 (2.0)	2,711 (8.4)
Neurological	618 (1.3)	59 (0.4)	559 (1.7)
Mortality, n (%)			
The day of surgery	780 (1.7)	11 (0.1)	769 (2.4)
Within 7 days	4,039 (8.5)	142 (1.0)	3,897 (12.1)
Within 30 days	6,303 (13.3)	264 (1.8)	6,039 (18.7)
Within 90 days	7,973 (16.9)	345 (2.3)	7,628 (23.6)
Within 365 days	10,366 (21.9)	517 (3.4)	9,849 (30.5)

ICD = International Classification of Diseases; IQR = interquartile range.
a) The 5 most common ICD-10 chapters.

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27.5%) (Supplemental digital content 4 [14]). The ten most frequent surgical codes made up 70% of the major laparotomy group (Supplemental digital content 5 [14]). The number of patients in the minor laparotomy group decreased in the study period (Supplemental digital content 6 [14]).

Primary and secondary outcomes

The overall seven-, 30-, 90- and 365-day mortality was 8.5% (95% CI: 8.3-8.8%), 13.3% (95% CI: 13.0-13.6%), 16.9% (95% CI: 16.6-17.2%) and 21.9% (95% CI: 21.5-22.3%), respectively. The mortality risk was primarily dependent on the size of surgery (**Figure 1**). The seven-, 30-, 90- and 365-day mortality in the major laparotomy group was 12.1% (95% CI: 11.7-12.4%), 18.7% (95% CI: 18.3-19.1%), 23.6% (95% CI: 23.1-24.1%) and 30.5% (95% CI: 30.0-31.0%), respectively. The overall 30-day mortality was relatively stable throughout the study period although it increased in 2006 and the following four years (**Figure 2**). The 30-day mortality risk in the minor laparotomy group increased throughout the study period, whereas the risk decreased in the major laparotomy group (**Figure 3**).

A total of 7,521 patients (15.9%) had one or more

FIGURE 1

Survival curve of the one-year survival probability with 95% confidence interval stratified by minor (——) and major (——) laparotomy.

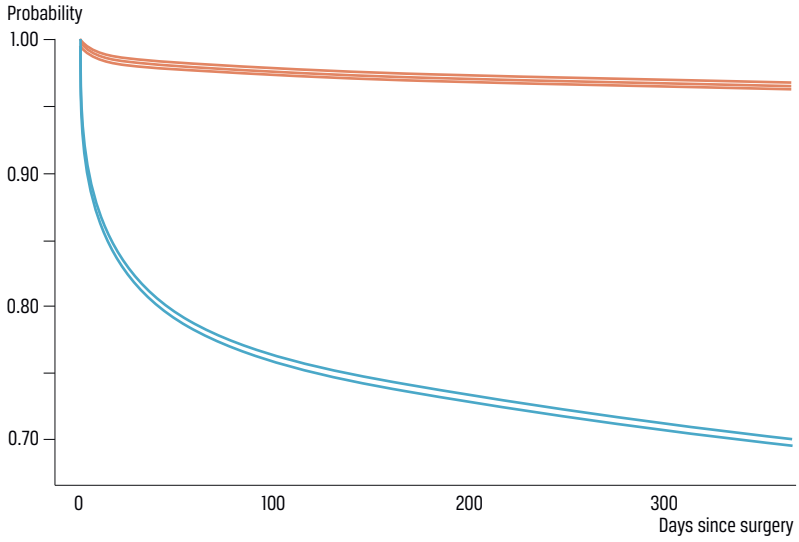
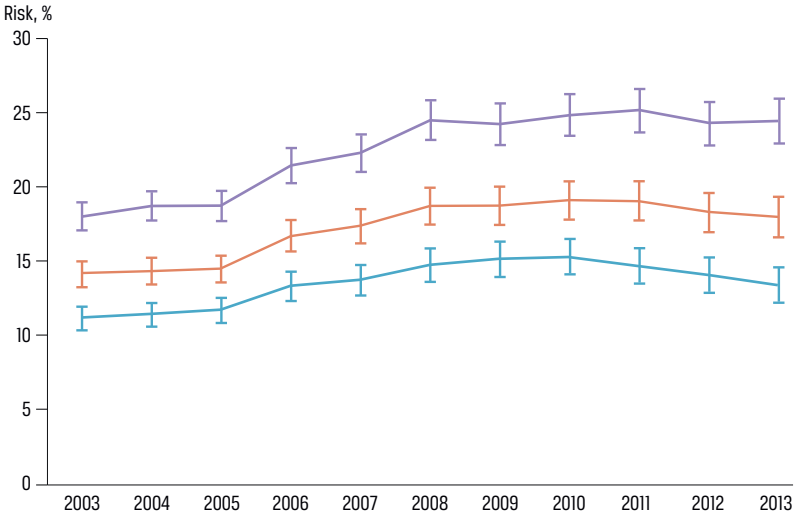


FIGURE 2

Mortality risk with 95% confidence interval after 30 (——), 90 (——) and 365 (——) days, by calendar year.



GI reoperations within 30 days of the index surgery. Of these, repair of wound dehiscence was the most common indication for reoperation (1,413 patients; 18.7%) followed by explorative laparotomy (1,175 patients; 15.6%). A total of 10,944 (23.1%) and 12,345 patients (26.1%) had a post-operative complication within 30 and 90 days, respectively. The most common complications within 30 and 90 days were infectious (5,489 (11.6%) and 6,324 (13.4%), respectively) (Table 1).

DISCUSSION

To our knowledge, this is the first nationwide population-based cohort study describing the short- and long-term outcomes following emergency laparotomy. The study population consisted of 47,300 patients, who were mainly elderly people suffering from several co-morbid conditions. Reoperations, readmissions and post-operative complications within 30 days of the operation were frequent, and the mortality risk was high. The post-operative outcomes depended largely on the size of the surgical procedure (minor versus major laparotomy).

The 30-day mortality was 13.3% in this study population. This is comparable with previous reports, which have shown 30-day mortality risks of 11-20% [1-7]. When excluding patients with minor procedures, the 30-day mortality increased to 18.7%, which is comparable with similar cohorts [1, 3, 4]. There is considerable variation in the definition of emergency laparotomy. Some studies do not include minor procedures such as open appendectomy and cholecystectomy [1, 3, 4, 6]. Others include laparoscopic procedures [6], making comparison difficult. We chose to include the minor procedure in order to present an overview of the post-operative outcome following open surgery and to be able to compare with previous findings. We divided the study population into a major and a minor laparotomy group because of the great variance in outcomes between these groups.

The major laparotomy group was very heterogeneous in the present study. It consisted of patients with 212 different surgery codes, and the complexity of the procedures varied. However, the ten most frequent surgeries constituted 70% of the major laparotomy group, making the heterogeneity less distinct. We chose this approach in order to investigate the outcomes following open surgery independently of the size and complexity of the procedure. We are unable to draw conclusions on outcomes at the level of the individual because of the heterogeneity of the population, which is a limitation to the study.

The number of patients in the minor laparotomy group decreased throughout the study period (Supplemental digital content 6 [14]), probably due to the increasing use of the laparoscopic approach. The mortality increased slightly throughout the study period, maybe because patients treated by an open approach have more complex conditions or atypical anatomy, making open surgery necessary [17, 18]. However, this hypothesis cannot be supported by the current data and needs to be examined in another study.

The 30-day mortality risk in the major laparotomy group decreased throughout the study period (Figure 3). In recent years, initiatives have been introduced to optimise the perioperative course for these patients.

The National Emergency Laparotomy Audit from the UK aims to improve quality of care by collecting data from National Health Service hospitals in England and Wales [6]. In Denmark, the Acute High-risk Abdominal Surgery study suggests that formal guidance for the perioperative course has a positive effect on post-operative outcomes [19]. The Danish study showed a reduction in 30-day mortality after the introduction of a standardised perioperative protocol for patients undergoing high-risk abdominal surgery. The results of the present study emphasise the need for national initiatives in order to improve the outcomes for this patient group.

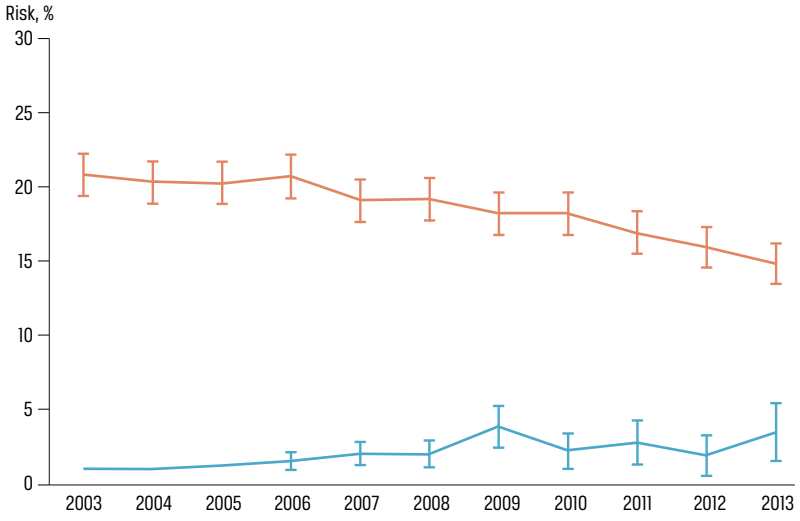
This study has several strengths. It is, to our knowledge, the first nationwide population-based cohort study to include all emergency laparotomies in an 11-year period. It was based on Danish registers, enabling us to include all Danish residents and achieve complete follow-up [12, 13]. The registers give a unique opportunity for research of the long-term outcomes following surgery.

This study has limitations which should be considered. It was an observational study based on national administrative data and it contains fewer clinical parameters than studies based on chart reviews or clinical studies. The data were not collected specifically for the purpose of this study, and the study population was identified from surgical codes, which means that there is a risk of lacking patients due to coding errors. However, data from the NPR have previously been validated and surgery codes such as appendectomy and cholecystectomy have a positive predictive value of 99% [12]. Another limitation is that surgeries are not classified as elective or acute in the NPR. We used information of admission mode (acute) and time from admission to surgery (< 72 hours) as our definition. We required a minimum of four hours between the index surgery and the reoperation in our definition of a reoperation. This might result in underreporting of reoperations for immediate complications such as intraoperative bleeding. Furthermore, we only considered readmissions registered as acute, which results in exclusion of patients with complications treated in outpatient clinics and eventually requiring non-acute readmissions. This might result in underreporting of post-operative readmissions.

This is the first nationwide cohort study on patients undergoing emergency laparotomy. The study reveals a high level of both short- and long-term mortality, especially among patients undergoing major procedures. A large number of patients are readmitted or re-operated. There is a need for studies examining predictive factors for adverse outcomes in order to design preventive medical or organisational measures.

FIGURE 3

The 30-day mortality risk with 95% confidence interval by calendar year for minor (——) and major (——) laparotomies.



CORRESPONDENCE: *Maja Mønster Jeppesen.*
E-mail: majajeppesen@me.com
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